UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
OFFICE OF OCEANOGRAPHY AND MARINE ASSESSMENT
OCEAN ASSESSMENTS DIVISION
Rockville, MD 20852

JAN 10 1985

Mr. Gerard Sotolongo
U.S. Environmental Protection Agency
Region I--Superfund Branch
Room 1907
JFK Federal Building
Boston, MA 02203

Dear Mr. Sotolongo:

The National Oceanic and Atmospheric Administration (NOAA) has reviewed the August 1984 draft "Feasibility Study of Remedial Action Alternatives for the Acushnet River Estuary Above Coggeshall Street Bridge in New Bedford, Massachusetts," and its addendum. Our comments on the remedial alternatives presented in those documents for the removal or isolation of the polychlorinated biphenyls (PCBs) currently contaminating the estuary are enclosed.

We have evaluated the advantages and disadvantages of each alternative and concluded that, with certain adjustments, any of the three dredging with on-site disposal alternatives are acceptable. Our preferred alternative among the three, providing some apparent deficiencies can be resolved, is the subsurface cell disposal plan which minimizes long-term changes to the upper estuary.

NOAA and the Commonwealth of Massachusetts, as trustees for natural resources, have filed a claim against the parties responsible for the PCB contamination of the Acushnet River estuary under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980. We are currently preparing a joint assessment of the damages to natural resources resulting from this contamination. NOAA's comments on the New Bedford Remedial Investigation/Feasibility Study (RI/FS) reflect both our concerns as a natural resource trustee and recognition of the close relationship between EPA's remedial actions and any restoration undertaken by the trustees. We have worked closely with your agency on all aspects of this case to date and look forward to continuing cooperative efforts to address the problems arising from the PCB contamination of the Acushnet River estuary.

If you have any questions about our comments or recommendations, please contact George Kinter of the Ocean Assessments Division. He can be reached by telephone on FTS 443-8465.

Sincerely,

Charles N. Ehler

Charles N. Ehler
Chief

Enclosures

COMMENTS OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION ON THE AUGUST 1984 DRAFT "FEASIBILITY STUDY OF REMEDIAL ACTION ALTERNATIVES FOR THE ACUSHNET RIVER ESTUARY ABOVE THE COGGESHALL STREET BRIDGE IN NEW BEDFORD, MASSACHUSETTS," AND ITS ADDENDUM

Any remedial action for the PCB contamination of the Acushnet River estuary should, in the view of the National Oceanic and Atmospheric Administration (NOAA), not only alleviate the immediate public health threat, but also return the estuary to the extent possible to its pre-contaminated state so that normal functions, including biological activities (e.g., spawning and nursery areas), recreational uses, fishing, and operation as a commercial port, can be fully resumed. The selected remedy should minimize further risks to public health or the environment (e.g., through airborne emissions, resuspension of contaminated sediments, or unnecessary destruction of wetlands or other ecologically important areas) during implementation. If disposal of the contaminated sediments is chosen, the remedy should ensure the integrity of the disposal site to prevent future releases. Finally, the remedy selected for the upper estuary should, to the extent possible, facilitate cost-effective cleanup of contaminated "hot spots" in the lower estuary.

Apart from the unacceptable "no action" alternative, all of the other alternatives discussed meet many of the above criteria to varying degrees. All involve environmental, as well as economic, trade-offs.

Upland Disposal of Contaminated Sediments

NOAA would normally favor the remedy that removes the contamination from the marine environment, but recognizes in this case that upland disposal of the contaminated sediments may pose greater risks to useable groundwater than on-site disposal, since the aquifer underlying the Acushnet River estuary is apparently saline. Unless a suitable upland site can be found in Massachusetts or elsewhere that minimizes any risk to freshwater aquifers, we do not believe the benefits of this alternative outweigh the risks.

Incineration and Other Means of Destroying PCBs

Destruction of the PCBs in the sediments through incineration might offer the best long-term solution were it not for the presence of elevated levels of toxic metals in the same sediments. Rather than being destroyed by incineration, some of these may become more toxic and more bioavailable than they are at present, presenting new risks. Other more acceptable ways of destroying or degrading PCBs that offer better long-term solutions than disposal may be available, including the use of biological or chemical agents. We urge EPA to investigate these experimental technologies more thoroughly before selecting a final remedy.

Hydraulic Control/Sediment Capping

Of the on-site isolation and disposal options, the hydraulic control/sediment-capping alternative will minimize dredging and any associated resuspension of the contaminated sediments, but will also drastically alter the hydraulic regime of the upper estuary and destroy much of its remaining potential as spawning and nursery areas. We also question whether this alternative will adequately isolate highly contaminated areas of the upper estuary from tidal or river flooding under exceptional storm conditions. Finally, the alternative provides no disposal area for contaminated sediments removed from the lower estuary. For these reasons, we cannot support it.

Dredging and On-Site Spoil Disposal

Two other remedial alternatives involve removal of the contaminated sediments by dredging and on-site disposal of the resulting spoil somewhere in the upper estuary, either in a lined or partially lined site. We question the need for a fully lined site if there is little risk of PCBs migrating from the disposal site into useable freshwater aquifers. Both alternatives would transform some of the upper estuary into upland, permanently destroying wetlands in that area. In this connection, we are pleased that EPA plans to evaluate the wetlands and other areas of ecological importance in the upper estuary with the intention of finding a disposal area that will minimize such damage. Reestablishment of viable wetlands wherever tidal waters meet the edges of the selected disposal site may also be possible. Because extensive dredging will be required, both options risk resuspending and dispersing contaminated sediments. To minimize these risks, EPA will need to monitor the dredging operation and the effectiveness of the sediment dispersal control structures installed at the Coggeshall Street Bridge closely in order to stop operations and make technical adjustments if sediment resuspension exceeds acceptable levels.

Both alternatives have the advantage of providing additional disposal capacity for contaminated sediments removed from other areas in the estuary. If either is selected, planning should include the projected removal of contaminated sediments from the lower estuary. In this way, the overall costs of disposal can be reduced. If steps are taken to minimize damages to the potentially most productive wetlands in the upper estuary and minimize risks of resuspension and dispersion of contaminated sediments, we find either dredging and on-site spoil disposal option acceptable.

On-Site Disposal in Sub-Surface Cells

The sub-surface cell option presented in the addendum appears to minimize long-term changes to the upper estuary, including its wetlands, while providing adequate integrity of the storage site. But we have a number of concerns about this alternative. It appears to pose the greatest risk of resuspension of contaminated sediments during implementation and, like the other alternatives involving dredging, will require constant monitoring and possibly technological adjustments to keep those risks within acceptable levels.

We are also concerned that there may be some displacement of the contaminated sediments when clean sediments are placed on top of them in a subaqueous site. For your information, we are attaching a paper (Bokuniewicz and Liu, 1981) prepared by scientists from the Marine Sciences Research Center of the State University of New York at Stony Brook. You may wish to contact them for more recent information on their work. Our final concern about the sub-surface disposal alternative is that it will apparently offer only limited disposal capacity for contaminated sediments from the lower estuary, but this problem might be solved by digging deeper cells. If these deficiencies can be resolved, this would be our preferred remedy.

Cost of Natural Resource Losses Resulting from Remedial Actions

As noted above, many of the remedial alternatives presented in the feasibility study will result in the temporary or permanent loss of wetlands and other natural resources. We believe that, once EPA has selected its remedial plan for the upper estuary, it should show any costs associated with damage to natural resources under the selected plan and, where feasible, their subsequent restoration, as part of its remedial costs. To avoid double counting, we will not include these costs in our assessment of natural resource damages unless EPA fails to include them in its remedial costs.

Attachment

Bokuniewicz, H.J., and J.T. Liu (1981). Stability of layered dredged sediment deposits at subaqueous sites. Oceans 81 Conference Record, Vol. 2. IEEE and Marine Technology Society, Washington, D.C.: 752-754

From: Oceans 81 Conference Record, Vol. Two. IEEE, New York and Marine Technology Society, Washington, D. C.: 752-754.

STABILITY OF LAYERED DREDGED SEDIMENT DEPOSITS AT SUBAQUEOUS SITES

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ABSTRACT

Covering, or capping, dredged-sediment deposits at subaqueous disposal sites is a technique to isolate contaminated sediment from the aqueous environment and to contain it on the site. After deposition, the sediments will consolidate with the expulsion of pore water and the layers may deform. If the deformation is extensive, the cap may be disrupted. Two conditions must be met for internal instability in the deposit; (1) the upper layer must be more dense than the lower and (2) the shear stress along the interface between the layers must exceed the strength of the deposit. Mathematically, the second condition is $\Delta\rho g h > (\alpha\tau)$ where $\Delta\rho$ is the difference in density between the layers, h is the height of irregularities in the interface between the layers and $(\alpha\tau)$ is the creep limit stress of the deposit. The creep limit stress is some fraction, α, of the shear strength τ. A deposit of dredged mud under a one-meter thick cap of sand might be expected to support irregularities about 1 m high.

1. INTRODUCTION

The prevalent methods for the disposal of dredged sediment are intended to enhance the containment of the dredged material at the disposal site rather than to maximize its dilution and dispersion. For disposals of contaminated sediments it is often mandatory that the operation be designed not only to contain the dredged sediment in a small area, but also to isolate the dredged material from the environment as much as possible. One of the strategies for isolating and containing contaminated sediment at subaqueous disposal sites involves covering, or capping, the contaminated sediment with clean, or relatively uncontaminated, sediment. The contaminated sediment is likely to be mud because of the association of some of the more troublesome pollutants with fine-grained sediment particles. The capping material may be uncontaminated mud or sand. The capping strategy has been used recently at several sites in the waters along the northeast coast of the United States.

In 1973, New Haven Harbor, CT, was dredged and the dredged sediment was placed at an open-water disposal site in Long Island Sound. Dredging was begun in the inner harbor where the most contaminated mud was found, so this material would be put on the disposal site first. The last material that was deposited on the site was relatively uncontaminated, sandy sediment from the outer part of the channel. A compact deposit was created but the extent to which the inner harbor mud was covered by the sandy sediment was not documented. The surface of the deposit, however, was sandy mud that was characteristic of the last sediment to be dredged. A more elaborate capping operation was completed recently near the same site in Long Island Sound.[1] Point dumping was used to create two mounds of dredged mud on the Sound floor. One of these was covered with a thick layer of mud and the other was capped with a layer of sand. Another capping operation has been started at a disposal site off the New Jersey coast using dredged mud from New York Harbor, and a small project is planned to fill partially a submarine, mined pit in the Lower Bay of New York Harbor with dredged mud and to cap the mud deposit with sand.

Although the technology is available to construct subaqueous layered deposits of dredged sediments, the long-term fate of such deposits deserves attention. One concern is that the layered deposit may be internally unstable. A sand-over-mud deposit may be inherently unstable, for example, because the sand layer will probably be more dense than the underlying mud. Under certain conditions the sand cap may deform allowing the sand to sink into the mud. If the deformation is extensive, the integrity of the sand cover could be disrupted and the contaminated mud exposed to the underlying water. The stability of a layered deposit of dredged sediments was the object of our study.

2. STABILITY CRITERIA

Soft sediment deformation is favored where the sedimentation rate is rapid, where sands and muds are interstratified, and where sands have porosities in excess of 44 percent.[2] All of these conditions would be characteristic of a capped deposit of dredged sediment. The overlying sand layer may subside into the underlying mud producing a structure known as a load cast or the sand and mud may convolute producing a feature called a ball and pillow structure. Although the mechanics of soft sediment deformation have not received much attention from geologists, an estimate of the stability of a capped, dredged sediment deposit can be made as an integration of the results of previous studies in geology and geotechnology.

Two conditions must be met for convective instability to arise in a capped deposit of dredged mud.[3] The first is that the upper layer (the cap) must be more dense than the lower. The second condition is that shear stresses along the interface between the layers must be greater than the strength of the layered deposit. If the interface is irregular and the height of the irregularities is h then the magnitude of the shear along the interface is $\Delta\rho g h$ where $\Delta\rho$ is the density difference between the layers. For motion to start $\Delta\rho g h$ must be larger than some critical value.

Artyushkov[3] defined the critical value to be the maximum of the values of the shear strength for both layers; Pettijohn, Potter, and Siever[4] suggested that it should be the shear strength between the two layers. The shear strength of a sediment is usually given as the greatest stress that the material can withstand in a short-term, laboratory test before it fails, or undergoes continuous deformation. Some terrestrial soils and marine sediments, however, will deform under stresses that are significantly less than their short-term shear strength.[5,6] The actual design strength for such material is called the creep limit; the creep limit is the maximum stress level that does not cause long-term, continuous creep deformation.[7] In tests done on two marine sediments, the creep limit was found to be 40% and 60% of the sediments' short-term strength and the creep behavior of these marine sediments was found to be similar to the response of creep-susceptible terrestrial soils.[6] In applying the stability criteria to a two-layered deposit of dredged sediments, it would seem reasonable to assume that the critical value of $\Delta\rho g h$ must lie between the creep limits of the two sediments in the deposit.

The value of h is then a measure of the degree of stability of the deposit. A small value indicates an unstable deposit while a larger value would characterize a deposit that is more stable. The degree of stability depends not only on the types of sediment that comprise the deposit, but also upon the geometry of the sediment layers. The irregularities in the interface, for example, could occur on any length scale, but we might expect that the growth of irregularities in the deposit will be most rapid for irregularities over a particular length range which depends upon the thickness of the layers. This is the case for instabilities that arise between two layers of viscous liquids when the upper layer is more dense than the lower layer; for such a layered, viscous medium, there is a particular wavelength to those irregularities in the interface that will increase in amplitude most rapidly as a convective instability. For liquids, the critical wavelength is usually between several times the thickness of the layers to several tens of times the layer thickness.[3,8] By analogy to convective instabilities in liquids, we will assume that h is the change in level of the sediment interface over distances between several times the thickness of the layers and several tens of times the layer thicknesses.

The geometry of the sediment layers also influences the degree of stability in another way, because both the density contrast and the strength of the deposit will change as the thickness of the upper layer changes. The density of either layer will increase as the layer consolidates under its own weight (self-consolidates) and density of the lower layer will further increase as it consolidates under the weight of the upper layer. The consolidation may be predicted from the general theory of the deformation of a permeable elastic medium[9] using an empirical, consolidation coefficient that is determined by the standard, laboratory consolidation test. The settlement (or the change in thickness) due to the consolidation of one layer under its own weight (self-consolidation) is $a(\rho-\rho_o)gH^2/2$ where a is the empirical consolidation coefficient, ρ and ρ_o are the bulk density of the sediment and the density of water respectively, and H is the thickness of the layer. The consolidation of the lower layer under the weight of the upper layer is $a(\rho_u-\rho_o)gH_uH_l$ where the subscripts u and l refer to the upper and lower layers respectively. After the consolidation of the deposit is complete the density contrast, $\Delta\rho$, between the two layers will be $\rho_u/(1-W_u/H_u) - \rho_l/(1-W_l/H_l)$ where W_u and H_l are the final settlements of the upper and lower layers respectively.

The strength of the deposit will also increase under the weight of the upper layer. The shear strength, τ, is given by $\tau = c + N \tan\phi$, where c is the cohesion resulting from the physiochemical bonding between particles in the sediment, N is the effective weight of the overburden and ϕ is called the angle of internal friction of the sediment, which is the measure of the mechanical resistance to the sliding of one particle past another. At the interface between the layers, the effective overburden, or the submerged weight of the cap, is $(\rho_s-\rho_o)gH_s$. A thicker capping layer should result in a higher value for τ. The creep limit may also be expected to increase under the weight of the overburden, although no tests have been done on marine sediments to examine this phenomenon directly. For some terrestrial soils, however, it has been shown that the creep limit is approximately equal to the soil's residual strength which is defined to be the ultimate strength of the soil after it has undergone several failures in its past geologic history.[7] The residual strength should include only the frictional component of the strength because the cohesion is almost totally destroyed as a result of successive failures and large displacements over the same failure plane.[5,7] If the correspondence between the creep limit and the residual strength also exists in marine sediments, then the creep limit would be given by $N \tan\phi$. Until more research is done, however, perhaps the better assumption is to estimate the creep limit as $\alpha\tau$ where $\alpha = 0.5$ based on the few available experiments.[7]

3. SAMPLE CALCULATION

A numerical example may be helpful and will also serve to illustrate a difficulty in the application of the theory. Consider a layer of mud 2 m thick covered by a one-meter thick layer of sand. In order to determine reasonable values of the critical sediment parameters, core samples were taken and analyzed. A core sample of sand was taken from the Lower Bay of New York Harbor and was found to have a density of 1.8 Mgm/m^3. A sample of dredged mud was taken from a disposal site in central Long Island Sound. The density of this material was 1.5 Mgm/m^3. A standard consolidation test was done on the mud sample; the value for the consolidation coefficient was found to be about 5×10^{-3} m^2/kN. We will assume that the sand is incompressible.

It is difficult to assign an appropriate value for the shear strength of the deposit. In principle, values for c and ϕ that describe the shear strength at the sand-mud interface might be used but, in practice, this is not easy to measure. Furthermore, in an actual deposit it is unlikely that the transition from sand to mud will be sharp; the transition is more likely to be a gradual one. The shear strength of the sand just above the interface will be different from that of the mud just below and, as a first approximation, we will assume that sandy mud (or muddy sand) in the transition zone will have a shear strength between that of clean sand and that of mud. Sand is usually found to be cohesionless ($c = 0$) with an angle of friction of about 35°. The shear strength of the mud samples was measured with a vane tester after compaction under various loads. These tests showed c to be 2 kN/m^2 and ϕ to be 15°. The sand layer is assumed to be 1 m thick so that the shear strength in the transition zone between the sand and mud should be between 5.5 and 4.0 kN/m^2. The creep limit should then be between 2.8 and 2.0 kN/m^2. The increase in the density of the mud due to consolidation is small. The mud density will increase about 4% at the sand-mud interface and about 9% at the base of the mud layer. The strength of the deposit with these characteristics will be sufficient to support irregularities in the sand-mud interface smaller than a critical value of h between 0.8 and 1.4 m high. The lateral extent of these irregularities is estimated to be between 5 and 60 m.

4. DISCUSSION

According to the criterion discussed here it appears to be possible to construct a stable deposit using conventional techniques. At the central Long Island Sound disposal site a capped deposit of dredged sediment has been created.[1] The deposit is a mound of dredged mud, with a maximum thickness of about 2.0 m, covered by a blanket of sand with a maximum thickness of 3.5 m. Bathymetric surveys show irregularities in the sand-mud interface to be up to 1.2 m high and about 25 m across. If the properties of this material can be assumed to be the same properties as those used for the sample calculation, the deposit is probably stable and should not be subject to large-scale, internal deformation. The difference between the observed irregularities and the calculated height of the critical irregularity is small enough, however, to warrant more careful study. One problem is that the thickness of the sand cap is not uniform. As a result, the overburden at the sand-mud interface will not be uniform and the degree of instability will vary from place to place along the interface. Another problem is that the strength of the deposit may also be reduced by an increase in the interstitial pressure because of gas generation or the effects of storm surges over the deposit.[10] These effects have not been investigated here but they deserve attention.

5. ACKNOWLEDGEMENTS

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